THURSDAY, SEPTEMBER 2, 1886

CHEMICAL PHYSICS

Elements of Chemical Physics. By Josiah P. Cooke, Jr., Erving Professor of Chemistry and Mineralogy in Harvard University. Fourth Edition. (London: Macmillan and Co., 1886.)

THE preface to this work bears the date Feb. 1, 1860; no explanation is given of the issue in 1886 of a *fourth* edition in the form before us. According to the dictionary, an edition is "the whole number of copies of a work published at once." We are forced to assume that such a definition would be accepted as sufficient by Prof. Cooke; but in the case of educational works dealing with a branch of science which is daily enriched by new discoveries, the reading public are in the habit of supposing that a *new* edition is not a mere reprint of the former edition: it is rightly expected that it shall take notice of, at all events, the more important of recent discoveries, and failure to recognise this elementary truth is unpardonable.

It is a grave injustice to put into the hands of the innocent student a book dated 1886 which was first issued in 1860, and without informing him that he is to learn nothing of the classical discoveries in chemical physics made during the past quarter of a century: on advancing to do battle in the ranks of science he would be about in the position of our old wooden walls in face of modern ironclads and torpedo-boats.

The work is divided into five chapters, the first (9 pp.) being introductory. Chapter II. (107 pp.) deals with the general properties of matter; Chapter III. (309 pp.) is on the three states of matter; heat is the subject of Chapter IV. (235 pp.); and Chapter V. (24 pp.) is on weighing and measuring. The volume is intended—according to the 1860 preface—to furnish a full development of the principles involved in the processes of weighing and measuring small quantities of matter; subsequent volumes were to treat on light in its relations to crystallography; on electricity in its relations to chemistry; and on stoichiometry and the principles of chemical classification; but we are not aware of their issue. Unlike most text-books, it is a most readable work, containing much interesting matter, and is admirably printed; hence it is particularly to be regretted that it presents so imperfect and antiquated an account of the subjects treated of. In justification of this statement we may point out that the latest reference to experiments on the condensation of gases is to those of Natterer. Andrews's great discovery of the critical point is nowhere referred to. Regnault's determinations of the specific heat of carbon in its three forms are quoted, but not a word is said of Weber's important investigation on this subject; in the section in which the methods of determining specific heat are described no reference is made to Bunsen's beautiful method; and the word dissociation nowhere occurs, the classical discoveries of Deville and his school being unmentioned. One inaccuracy requires special mention. We are told (p. 428) that, "According to the modern theory of chemistry, equal volumes of all substances in the state of gas contain precisely the same number of molecules, *or, what amounts to the same thing, the molecules of all bodies in the state of gas occupy exactly equal volumes.*" The latter part of the sentence, which we have italicised, is obviously unmitigated nonsense, yet it is a statement which perpetually haunts us. A well-known standard text-book of chemistry from which probably a very large proportion of our youth gain inspiration in fact tells us almost in the same words that "the relation existing between the volumes of gases when they combine together has been found to be a very simple one, inasmuch as the densities of all elements known in the gaseous state are identical with their atomic weights; *or, what is the same thing, the atoms in the gaseous state all occupy the same space* (Gay Lussac, Avogadro)." Could anything be more misleading and inaccurate, since mercury, phosphorus, sulphur and iodine are all known "in the gaseous state"? It cannot be too clearly stated that the *chemist* only concerns himself with the *relative weights* of atoms and molecules, and that Avogadro's law only has reference to the *relative numbers* of molecules in equal volumes of gases, their size being altogether left out of account: no notice being taken, in fact, of the space which the stuff itself occupies. Our notions on the subject of the size of molecules and atoms are of the very vaguest at present, and even Sir William Thomson has not ventured, we believe, to consider the differences in size of molecules of different kinds: for the most part they certainly cannot be of the same size. The popular method of teaching the volumetric relations between gases is probably the cause of the error now referred to being steadily perpetuated. The ordinary student more often than not will insist—very naturally—in regarding the term volume as representing a specific quantity: being taught, moreover, to consider the symbol of a compound gas as equivalent to "two volumes," he extends the idea of volume to the elementary symbols and naturally enough concludes that if I_2, for example, represent *two* volumes, I must represent *one* volume; hence it is difficult to make him realise that a change such as is represented by the equation $I_2 = I + I$ involves a doubling of the volume. Again, the common practice of speaking of compound gases as *containing* certain volumes of the constituent gases is both misleading and inaccurate: for example, it is found that the gaseous density of phosphorus is such that its molecular composition is expressed by the formula P_4: this represents "two volumes," and so the symbol P is said to represent "half a volume," and we are then gravely told that "two volumes" of phosphuretted hydrogen *consists* of or *contains* "three volumes" of hydrogen and "half a volume" of phosphorus. Some teachers engrave the error still more deeply upon the student's mind by performing before him a kind of Jack-in-the-box trick, picking out from a box on which the symbol of the compound is painted a series of boxes which in number and size are supposed to represent the volume of the elements contained in the compound. All that we really know is that a given bulk of a particular gas will decompose into, or can be formed from, certain bulks of the constituent elements: that phosphuretted hydrogen, to take the example cited, on decomposition yields one and a half times its bulk of hydrogen and half its bulk of phosphorus gas. The only method by which we could endeavour to form any estimate of the relative volume occupied in a compound by the constituent atoms would be by taking the molecular volume of the compound and the atomic volumes of the constituents into account; but this is never done. It would be a great advantage if we were to cease using the term *volume* when speaking of gases, and were to treat all questions concerning changes in volume from a dynamical point of view: Avogadro's law tells us, in fact, that, in every change in which gases are concerned, the variation in the space required to contain the gases—pressure and temperature remaining constant—will be directly as the variation in the number of gaseous molecules. If the equation be written which expresses the change, care being taken to employ the symbols which represent the molecular composition of the gaseous substances concerned in it, it is merely necessary to add up the number of molecules of the gaseous substances appearing on either side: the two sums will give the ratio of the volumes before and after change. By our present practice thoroughly false conceptions are engendered: a fundamental principle of our science is most unscientifically taught: and yet when we come to examine we marvel at the stupidity displayed by the examinee when dealing with simple questions of volume change!

It will be in place here to inquire—What is *chemical physics?* To judge from the books on the subject, we are probably justified in defining it as a milk-and-watery kind of physics specially prepared to suit the weak digestion and small appetite of the embryonic chemist; as a spineless kind of physics—physics without the solid backbone of mathematics. It is high time that it were recognised that he who wishes to be a chemist, and not the mechanical automaton who too frequently in this country goes by the name, must study physics seriously and properly: a mere smattering is of very little use. It is now incontestable that the sciences of chemistry and physics are inseparable: indeed the whole system of modern chemical theory reposes on a purely physical basis—that of Avogadro's law; and of late years the opinion has undoubtedly gained ground that the study of the physical attributes of pure elements and compounds must be carried on systematically and at the same time that their strictly chemical attributes are investigated, if we are ever to penetrate the veil of mystery which at present enshrouds the simplest chemical phenomena. Much work has already been done, and it is greatly to the credit of chemists that it has nearly all been executed by chemists who have been at the pains to study physical methods. Physicists have contributed comparatively little to the advancement of chemical physics, and it is undeniable that not a few investigations of importance to chemistry executed by physicists with the precision in measurement which characterises modern physical inquiry, are to a large extent labour spent in vain, as no guarantee has been given of the purity of the materials employed. Parenthetically it may be added that the physics as well as the chemistry of *pure* substances are fields of inquiry all but untrodden: the study of *pure* materials is *the* work of the future; and it is safe to say that when the results are recorded they will differ in many and important particulars from those now accepted. It is perhaps not undesirable to point out that a true conception of the meaning of the word *pure* does not always appear to be present in the mind of the chemist or physicist, otherwise the expression "chemically pure" would not so frequently occur. What is meant thereby, we presume, is that the substance is so nearly pure that the amount of impurity present does not perceptibly affect the results of quantitative analysis; but the amount of impurity present in a substance in such a case may exercise a most important influence on its chemical behaviour, and may also materially modify some of its physical properties. If, instead of distinguishing degrees of impurity, we continue to make this somewhat improper use of the word pure, it will be desirable also to speak of substances as being "spectroscopically pure," "electrically pure," &c., to indicate the nature of the test which they will pass.

To conclude, a book worthy to be called a treatise on chemical physics has yet to be written. It should contain a sufficiently detailed account of exact methods of determining the various physical attributes and the trustworthy results thus far recorded, together with a discussion of the bearing of these results on the problems of chemistry. It could hardly be the work of a single individual, but would doubtless require the co-operation of chemist and physicist. No mere compilation will suffice: to be of value it must be subject to the control of a chemist who is master of his science. Such a work would of necessity be of enormous service to students; and it would exercise an important influence on the progress of our science. HENRY E. ARMSTRONG

OUR BOOK SHELF

Madagaskar, und die Inseln Seychellen, Aldabra, Komoren, und Maskarenen. By Prof. Dr. R. Hartmann. (Leipzig and Prague, 1886).

THIS little work forms the fifty-seventh volume of "Das Wissen der Gegenwart," a scientific series which has already done so much for the spread of useful and accurate information amongst the Germanic populations. The author, himself personally acquainted with some of the localities here described, gives as clear and comprehensive an account of the various insular groups in the Indian Ocean as was possible within the available space of 150 pages. Of this space over two-thirds are devoted to Madagascar, whose physical constitution, natural history, ethnology, and political relations are treated with great ability. The best authorities, such as Grandidier, Shaw, Richardson, Sibree, and Hildebrandt, have been carefully consulted, and room has even been found for the discussion of such controversial questions as the existence of Sclater's vanished Lemuria, the origin of the Malagasy people, the affinities of their language, the presence in the island of the Vazimba and other aboriginal non-Malayan and Negrito tribes. Dr. Hartmann is inclined to accept the statements made by Commerson and Modave regarding the woolly-haired and dwarfish Kimo people of the southern districts, and suggests possible affinities either with the South African Bushmen or the Andamanese and Aeta Negritos of the Philippine Islands. The Malagasy he regards as essentially a mixed race, Polynesian, Malay, and African (especially Galla and Somali) elements being found diversely intermingled amongst the Hovas, Sakalavas, Betsimisaracas, and other native communities. The Comoros, Seychelles, and Mascarenhas (Mauritius, Réunion, and Rodriguez)